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(54) Title: VIDEO IMAGING SYSTEMS

(57) Abstract

Flow of traffic through an area is monitored by producing a video image of the area using a camera (10), dividing the video image into a matrix of pixels (23), sampling the pixels (23) of the whole video image at low resolution to detect changes in the pixels (23) which will indicate an object of interest and sampling the pixels of a local area (25) of the video image centred on said object of interest, at high resolution to detect the size of the object of interest and its direction of movement.

VIDEO IMAGING SYSTEMS

The present invention relates to video imaging systems and in particular
to a method and apparatus for monitoring the flow of traffic through an
area.

5   Video imaging systems have been proposed for monitoring the flow of
pedestrians entering or leaving a pedestrian traffic area, for example the
entrance to a retail outlet or shopping precinct. Such systems comprise a
video imager, for example a CCD camera which is positioned above the
area to provide a view of the traffic area, the images of the video imager
10   being analyzed by suitable processing equipment, to count the number of
pedestrians traversing the area and to detect the direction of movement
of the pedestrians. In order to reduce the processing capacity required, it
has been proposed in accordance with WO94/27408, to restrict
processing of the video image to only a narrow band of the traffic area.

15   This system may be tailored to accommodate, for example, obstructions
to the flow of traffic. However, once the system has been set up, it is
inflexible and would require resetting, if the traffic area is altered by the
introduction, removal or relocation of obstructions. Furthermore, such
systems can only measure bidirectional flow of traffic. If such systems
20   were to be used at an intersection, several systems would consequently
be required, one at each entrance to the intersection, in order to monitor
movement of the pedestrians through the intersection.

The present invention provides a video imaging system which is flexible
and will permit the monitoring of omni-directional traffic flow.

25   In accordance with one aspect of the present invention a method of
monitoring the flow of traffic through an area is characterised by;
producing a video image of the area; dividing the video image into a

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matrix of pixels; sampling the pixels of the whole video image at low
resolution to detect an object of interest; and sampling the pixels of a
local area of the video image centred on said object of interest, at high
resolution.

5   In accordance with a further aspect of the present invention, a video
imaging system comprises a video imager for producing a video image of
an area and processing means for analyzing the video image, said
processing means including; means for dividing the video image into a
number of pixels; means for sampling pixels at low resolution to detect
10   an object of interest; and means for sampling the pixels of a localised
area centred on said object of interest, at high resolution.

In accordance with the present invention, the whole of the video image is
scanned at low resolution, say one in every twenty pixels in both
directions, and only if an object of interest is located at low resolution, is
15   a localised area corresponding to the detected object of interest scanned
at higher resolution, thereby saving on the processing capacity required.

In this manner, when an object of interest is located, it may be tracked
across the area covered by the video image, so that omni-directional flow
of traffic across the area may be monitored. A single video imager may
20   consequently, for example, be used to monitor flow of traffic at an
intersection.

According to a preferred embodiment of the invention a series of time
separated video images of the area are produced, the pixels of one video
image being compared with the corresponding pixels of a preceding video
25   image or images, so that an object of interest moving across the area may
be detected by a change in the pixel.

Furthermore, the local area scanned at high resolution may be sized to the

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object of interest, so as to provide discrimination between different
objects of interest. For example, the local area scanned at high resolution
will differ depending on whether the object of interest is a child, adult or
pedestrian pushing a trolley or a family group. The sizing of the local area

5   scanned at high resolution, will also allow for discrimination between
individual pedestrians and closely grouped pedestrians. Corrections may
furthermore be made to the sized areas to accommodate variations due,
for example, to perspective or fish-eye lens effects. Alternatively the
changing shape of an object from frame to frame may be used to identify

10   the object. For example, for a pedestrian the stride pattern may be used
to distinguish between an adult and a child, while inanimate objects such
as trolleys will produce a regular pattern.

By continuously scanning the whole traffic area, albeit at low resolution,
the system will automatically accommodate changes in traffic flow paths

15   when, for example, obstacles are introduced or relocated in the traffic
area.

In accordance with a further aspect of the present invention, a video
imaging system comprises a video imager for providing a video image of
an area and processing means for analyzing the video image, said

20   processing means comprising means for dividing the video image into one
or more areas of interest, the processing means analyzing each area of
interest individually to detect the rate of flow and direction of movement
of objects of interest through each area of interest.

In accordance with this further aspect of the invention, a single video

25   imager may be used to monitor individually a plurality of areas of interest
in a given area. For example, the areas of interest may represent the
entrances to or exists from a lift, escalators and stairs. A single video
imager may thus be used to keep separate counts of pedestrians using
the lift, escalators and stairs, whereas hitherto separate means would

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have been required to monitor each area. Alternatively, the areas of interest may represent different counters of a retail outlet.

The invention is now described, by way of example only, with reference to the accompanying drawings, in which:-

5   Figure 1 illustrates diagrammatically, a video imaging system for monitoring the flow of pedestrians through a traffic area, in accordance with the present invention;

Figure 2 is a diagrammatic illustration showing the processing of the video image obtained by the system illustrated in Figure 1;

10   Figure 3 illustrates diagrammatically a video imaging system similar to that illustrated in Figure 1, installed at a pedestrian intersection;

Figure 4 illustrates diagrammatically an alternative application of the video imaging system in accordance with the present invention; and

Figure 5 illustrates diagrammatically a further embodiment of the present
15   invention.

As illustrated in Figure 1, a video imaging system for monitoring the flow of customers in, for example supermarkets, comprises a monochrome or colour CCD camera 10 which is mounted over an isle 14 of the supermarket. Cabinets 16 are located on either side of the isle 14. The
20   camera 10 is mounted to look vertically down on the area 12 which may, for example, be 10 metres square.

The camera 10 is connected to a remote processing means 20 which comprises an analogue to digital converter 21 which converts the analogue signal from the camera 10 into a digital signal representing the

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video image. The video image is divided into pixels, each representing a
tiny dot on the video image. The digital signal includes a digital value
corresponding to the shade of grey (for monochrome) or colour of each
pixel. The video image of the area 12 comprises a matrix 512 x 512

5   pixels. The camera 10 produces a new video image of the area 12 at a
rate of 25 frames per second.

The digital signals of each frame of the video image are passed to
memory and analyzing means 22, which scans every twentieth pixel 23
of the matrix in each direction and compares the digital value

10   corresponding to the shade of grey or colour of each pixel 23 with that of
the same pixel in the preceding frame. Alternatively the digital value of
each pixel may be compared with a weighted average of the digital value
of that pixel during an arbitrarily long period of say 255 frames. If there
is a variation in the shade of grey or colour which is in excess of a

15   threshold value, then a potential object of interest, that is a moving
object, is detected. The threshold may vary at different light intensities
and the ability to differentiate changes at high and low intensities may
change. Threshold maps may be used to control the threshold for
different areas of the image.

20   In order to avoid the false detection of objects of interest due to local
fluctuations in light, upon detection of a potential object of interest, pixels
adjacent to the pixel 23 indicating a potential object of interest are
scanned and only if there is a change in the shade of grey or colour above
the threshold value, of at least one of these adjacent pixels, is the object

25   of interest confirmed. Furthermore, in order to avoid the false detection
of object of interest due to variations in light over the area 12 as a whole,
the variation in shade of grey or colour of the pixel 23 identifying the
potential object of interest, is compared with variations of pixels 23 in
other parts of the area 12 which include, for example, pixels 23 in parts

30   of the area 12 in which the display cabinets 16 are located and cannot

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possibly include objects of interest.

Upon confirmation of an object of interest, the analyzing means then
scans all the pixels in a local area 25 which is centred on the pixel 23
identifying the object of interest. The local area 25 may initially be of a
nominal size corresponding to a typical adult pedestrian. The size of the
local area 25 may however be increased or reduced until the local area 25
is sized to the object of interest. The local area 25 is also moved until it
covers the object of interest. That is, the local area 25 is adjusted until it
covers all adjoining pixels in which there has been a change in the shade
of grey or colour above the threshold value.

The object of interest may be identified by the size of the local area 25
which is eventually found to be required to cover the object of interest.
The size and shape of the object of interest will change as the pedestrian
moves and, for example, his arms and legs move relative to his body.
Such variations may however be taken into account when identifying the
object of interest by, for example, averaging the size over several frames
of the video image. The processing means 20 is provided with memory
means 24 in which look up tables are stored by which objects of interest
in different size ranges would be identified as, for example, children,
adults, adults pushing pushchairs or supermarket trolleys or closely
grouped pedestrians. In the latter case, the overall size of the group may
be used to provide a number in the group. The threshold value will
discriminate between solid objects and shadows in the video image, thus
avoiding false identification of the objects of interest. Where however
intense shadows are formed by an intense light source, the threshold
value may not be sufficient to discriminate between the solid object and
shadow. The system may however be programmed with the position of
such light sources, so that the location of a shadow may be predicted and
discounted.

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The local area 25 moves with the object of interest as it traverses the
area 12 and thus the direction of movement of the object of interest may
be monitored.

With the system disclosed above, if an object of interest comes to rest in
5   the area 12 it will merge into the background. In such cases, it is
necessary to maintain a record of the position of the object of interest
and where it came from, so that when the object begins to move again,
its path across the area 12 may be detected. One method of achieving
this is that once a pixel detects an object of interest, the digital value
10   against which the digital value of the pixel is compared is frozen until the
object of interest moves away from that pixel. This protection of
stationary objects of interest will preferably be of limited duration so that
new obstructions permanently introduced into the area 12 will eventually
be permitted to blend into the background.

15   The system disclosed above may consequently be used to monitor the
number, type and direction of shoppers moving along the aisle 14.
Furthermore, as the system covers the whole of the area 12, if the
display cabinets 16 are moved so that customers may walk along the
areas hitherto covered by the cabinets 16 and/or further display means
20   are provided in the centre of the aisle 14, the system will automatically
adapt to the new flow paths of the customers, without having to be
reset.

In the embodiment disclosed above, the video image a frame of which is
illustrated in Figure 2 which typically represents an area 12, m x 10m, is
25   divided into a matrix of 512 pixels x 512 pixels. Each pixel will
consequently cover an area of about 2cm square. At course resolution
when every twentieth pixel 23, in each direction, is scanned, the
separation between the scanned pixels 23 will be about 40cms. This
compares to an average width of a pedestrian of about 60cms. Scanning

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at course resolution should consequently detect any pedestrians entering the area 12. However, the resolution at which the course scanning is carried out may be increased or decreased as required, depending on the area 12 that is covered by the video image, the relative size of the objects of interest and the number of pixels into which the image is divided. Scanning at course resolution will however preferably involve scanning between 5% and 10% of the pixels evenly over the whole area of the video image.

Furthermore, in accordance with the above embodiment, pedestrians may move across the area 12 at speeds up to about 3m/sec. Assuming that a typical pedestrian is about 30cm from front to back, each pixel traversed by the pedestrian would cover the pedestrian for about 0.1 seconds, that is at least two frames at a rate of 25 frames/second. Moreover, the pedestrian will progress across the area 12 by up to about 6 pixels per frame. The direction and path of movement of the pedestrian across the area 12 may consequently be tracked frame by frame.

In order to achieve real time processing of the video image, it is necessary to detect, confirm, size and position an object of interest between successive frames. Once an object of interest has been detected, sized and positioned, the size and position in one frame may be used to predict the size and position in the next frame, thereby reducing the amount of processing required in subsequent frames, to track movement of the object of interest across the area 12.

The analyzer 22 is capable of scanning a plurality of local areas 25 at the same time, so that a plurality of objects of interest transversing area 12 may be tracked simultaneously.

As illustrated in Figure 3, a video imaging system of the type described above may be used at an intersection 30 where two pedestrian

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thoroughfares 31, 32 intersect. With this system, as movement of the
pedestrians is monitored over the whole of the intersection 30, the
system is capable of monitoring pedestrians turning right or left as well as
going straight across the intersection 30.

5   In the embodiment illustrated in Figure 4, the camera 40 is positioned so
that it looks horizontally and downwardly along the main aisle 42 of a
supermarket. The system can thus monitor pedestrians moving along the
main aisle 42 and also turning off the main aisle 42 into one of several
aisles 44 leading from the main aisle 42. In this embodiment, in order to
10   accommodate perspective effects, the local areas 45 which are scanned
at high resolution after an object of interest has been identified at low
resolution, may be scaled.

The embodiment illustrated in Figure 5 is similar to the system illustrated
in Figure 1 and the same reference numerals are used for corresponding
15   components. In the embodiment illustrated in Figure 5, the overall area
12 covered by the camera 10 is divided into several areas of interest, a
first area of interest 52 corresponding to the entrance/exit from a lift 53;
a second area of interest 54 corresponding to the entrance to an up
escalator 55; a third area of interest 56 corresponding to the exit from a
20   down escalator 57; and a fourth area of interest 58 corresponding to the
entrance/exit from stairs 59.

The processing unit 20 is capable of processing each of the areas of
interest 52, 54, 56 and 58 independently, so that separate counts can be
obtained for pedestrians entering or exiting the lift 53, going up escalator
25   55, coming down escalator 57 and going up or down the stairs 59.

The areas of interest 52, 54, 56 and 58 are defined by the software of
the system and may be set by the operator upon installation of the
system. The areas of interest may furthermore be reset to accommodate

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changes in the physical layout of the area 12, without changing the
hardware of the video imaging system. Alternatively, the overall area 12
covered by the camera 10 may be divided into areas of interest
corresponding to, for example, different counters or display cabinets, so
5   that movement of customers from one counter or display cabinet to
another may be monitored.

While in the above embodiments the camera 10 produces a new video
image at a rate of 25 frames per second and the images are divided into a
matrix of 512 x 512 pixels, the camera 10 may alternatively produce
10   images at from 15 to 60 frames per second and the images may be
divided into matrices of from 80 x 80 to 4000 x 4000 pixels.

An additional video imager may be used to provide a stereoscopic image
which would allow depth perception. This would assist in the
identification of objects of interest and would also provide the capacity to
15   see around objects which may be obscuring other objects of interest.

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CLAIMS

1.   A method of monitoring the flow of traffic through an area (12)
characterised by; producing a video image of the area (12); dividing the
video image into a matrix of pixels (23); sampling the pixels (23) of the
whole video image at low resolution to detect an object of interest; and
sampling the pixels of a local area (25, 45) of the video image centred on
said object of interest, at high resolution.

2.   A method according to Claim 1 characterised in that the pixels (23)
of one video image of an area (12) are compared with the corresponding
pixels (23) of a video image or video images of the area (12) taken at a
different time, so that changes in the pixels will identify an object of
interest moving across the area (12).

3.   A method according to Claim 2 characterised in that video images
are produced at a rate of 15 to 60 frames per second.

4.   A method according to Claim 2 or 3 characterised in that the video
image is converted to a digital video image signal in which the video
image is divided into a matrix of pixels (23), the digital video image signal
containing a digital value for the shade of grey or colour of each pixel (23)
in the matrix.

5.   A method according to Claim 4 characterised in that the shade of
grey or colour of each pixel (23) of one video image is compared with the
shade of grey or colour of the corresponding pixel (23) in a preceding
video image and if the shade of grey or colour differs by more that a
threshold value, an object of interest is identified.

6.   A method according to Claim 4 characterised in that the shade of
grey or colour of each pixel (23) of one video image is compared to a

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weighted average of the shade of grey or colour of that pixel (23) during an arbitrarily long period, and if the shade of grey or colour differs by more than a threshold value, an object of interest is identified.

7.   A method according to Claim 5 or 6 characterised in that changes in each pixel (23) are compared with changes in other pixels (23) over the area (12) as a whole, so that corrections may be made for changes in light over the area (12) as a whole.

8.   A method according to any one of the preceding claims characterised in that detection of an object of interest at low resolution is confirmed by scanning pixels (23) adjacent to the pixel (23) at which an object of interest is detected, prior to the scanning of a local area (25) centred on the object of interest.

9.   A method according to any one of the preceding claims characterised in that at low resolution, between 5% and 10% of the pixels (23) are scanned evenly over the whole of the video image.

10.   A method according to any one of the preceding claims characterised in that the local area (25) is sized to the object of interest.

11.   A method according to Claim 10 characterised in that after locating an object of interest by scanning at low resolution, a local area (25) of nominal size is centred on the object of interest and the local area (25) is scanned at high resolution, the local area (25) being gradually sized to the object of interest over several high resolution scans.

12.   A method according to Claim 10 or 11 characterised in that the object of interest is identified from the size of the local area (25).

13.   A method according to Claim 10 or 11 characterised in that the

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object of interest is identified by variations in its shape from frame to frame.

14.   A method according to any one of the preceding claims characterised in that each video image is divided into a matrix of from 80 x 80 to 4000 x 4000 pixels (23).

15.   A method according to any one of the preceding claims characterised in that the video image is divided into a plurality of areas of interest (52, 54, 56, 58), each area of interest (52, 54, 56, 58) being scannable independently.

16.   A method for monitoring the flow of traffic through an area characterised by producing a video image of the area (12), dividing the video image into a plurality of areas of interest (52, 54, 56, 58) and processing the video image to detect independently, objects of interest in each area of interest (52, 54, 56, 58).

17.   A method according to Claim 16 characterised in that a series of time separated video images are produced, the video images being processed to detect the rate of flow and direction of movement of objects of interest, through each area of interest (52, 54, 56, 58).

18.   A video imaging system characterised by a video imager (10; 40) for producing a video image of an area (12; 30; 42) and processing means for analyzing the video image, said processing means (20) including means (21) for dividing the video image into a number of pixels (23), means (22) for sampling pixels (23) at low resolution to detect an object of interest; and means for sampling the pixels (23) of a localised area (25, 45), centred on said object of interest, at high resolution.

19.   A video imaging system according to Claim 18 characterised in that
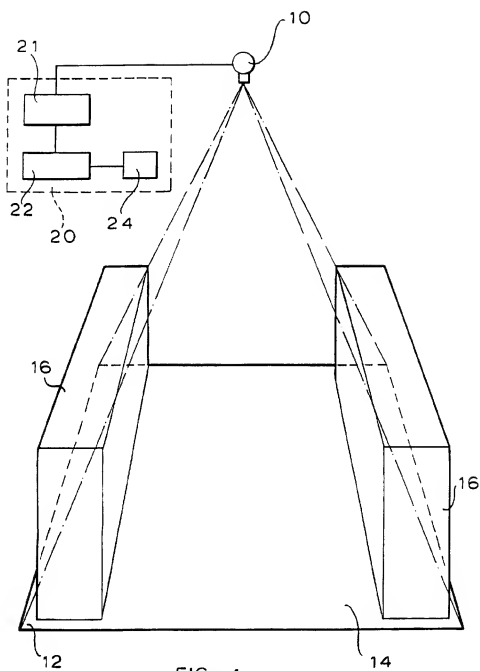
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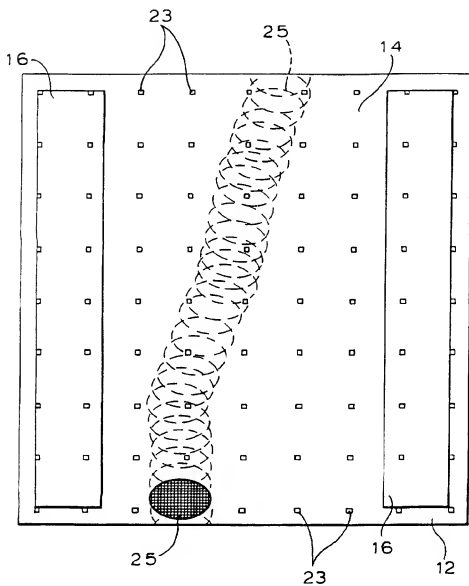the video imager (10; 40) is a monochrome or colour camera.

20.   A video imaging system according to Claim 18 or 19 characterised in that the video imager (10; 40) is disposed vertically, horizontally or in between the vertical and horizontal relative to the area (12; 30; 42).

5   21.   A video imaging system according to any one of Claims 18 to 20 characterised in that an additional video imager is provided to give a stereoscopic image of the area (42).
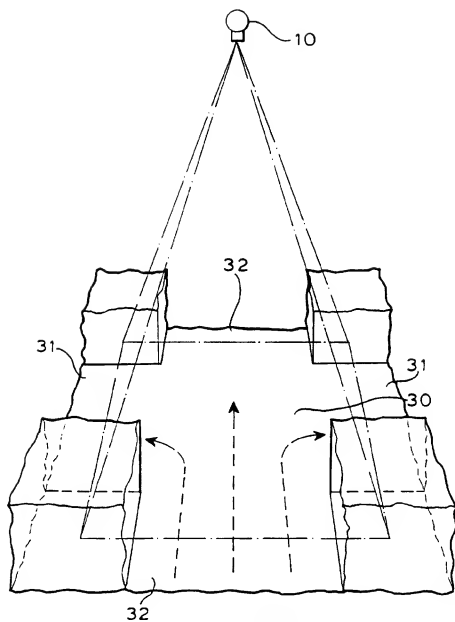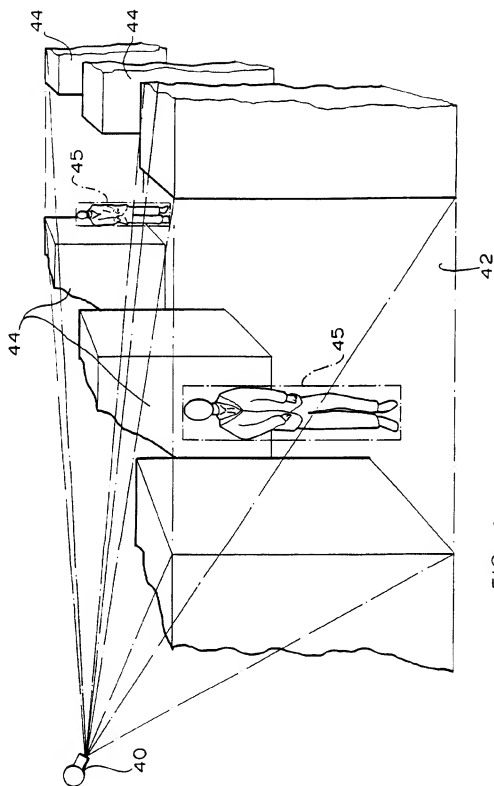
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FIG 1

FIG 2

FIG 3

FIG 4

FIG 5